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FORM PTO-1390 (REV. 9-2001) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY 'S DOCKET NUMBER	
P/1903-20	
U.S. APPLICATION NO. (If known, see 37 CFR 1.5)	
10/030463	
INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE
PCT/AT/00/00173	26 June 2000
PRIORITY DATE CLAIMED	
7 July 1999	

TITLE OF INVENTION: A LASER ARRANGEMENT

APPLICANT(S) FOR DO/EO/US: Alexander FURBACH and Ferenc KRAUSZ

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. [ ] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [X] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [ ] is attached hereto (required only if not communicated by the International Bureau).
   b. [X] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).
6. [X] An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. [X] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [X] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b. [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [X] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. [X] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [ ] A substitute specification.
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordan
18. [ ] A second copy of the published international application und
19. [ ] A second copy of the English language translation of the inte
20. [X] Other items or information:
    2 sheets of drawings.
    references
    PEFS print form
    Postcard

EXPRESS MAIL CERTIFICATE

I hereby certify that this correspondence is being deposited with the United States Postal Service as Express Mail Post Office Addressee (Mail Label EL EL924390194 US) in an envelope addressed to: U.S. Patent and Trademark Office, PO Box 2327, Arlington, VA 22202, on January 7,2002

Dorothy Jenkins
Name of Person Mailing correspondence

Dorothy Jenkins
Signature

January 7, 2002
Date of Signature

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
10/030463	PCT/AT00/00173	P/1903-20

21. [x] The following fees are submitted:	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	11 - 20 =	0	x **$18.00**	$
Independent claims	1 - 3 =	0	x **$84.00**	$
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$280.00**	$

TOTAL OF ABOVE CALCULATIONS =	$ 890.00	
[ ] Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. +	$	
SUBTOTAL =	$ 890.00	
Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)).	$	
TOTAL NATIONAL FEE =	$ 890.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +	$	
TOTAL FEES ENCLOSED =	$ 890.00	
	Amount to be refunded:	$
	charged:	$

a. [x] A check in the amount of $ 890. to cover the above fees is enclosed. Check No. 8018

b. [ ] Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [x] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 15-0700 . A duplicate copy of this sheet is enclosed.

d. [ ] Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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NAME

24,322
REGISTRATION NUMBER

P/1903-20

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

Alexander FÜRBACH et al

Serial No.:

Filed:

For: A LASER ARRANGEMENT

Date: January 7, 2002

Group Art Unit:

Examiner:

U.S. Patent and Trademark Office
P.O. Box 2327
Arlington, VA 22202

Attn: Box PCT (US/DO/EO)

AMENDMENT/SUBMISSION

Prior to examination, please amend the application as follows.

FEE CALCULATION

Any additional fee required has been calculated as follows:

_____ If checked, "Small Entity" status is claimed.

	NO. CLAIMS AFTER AMENDMENT		HIGHEST NO. PREVIOUSLY PAID FOR		EXTRA PRESENT		RATE	ADDIT. FEE
TOTAL	11	MINUS	20	* =	0	X	($9 SE or $18)	$
INDEP.	1	MINUS	3	** =	0	X	($42 SE or $84)	$
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM						X	($140 SE or $280)	$
* not less than 20 ** not less than 3							TOTAL $	-----

If any additional payment is required, a check which includes the calculated fee of $____ (OFGS Check No. _____) is attached.

In the event the actual fee is greater than the payment submitted or is inadvertently not enclosed or if any additional fee during the prosecution of this application is not paid, the Patent Office is authorized to charge the underpayment to Deposit Account No. 15-0700.

CONTINGENT EXTENSION REQUEST

If this communication is filed after the shortened statutory time period had elapsed and no separate Petition is enclosed, the Commissioner of Patents and Trademarks is petitioned, under 37 C.F.R. § 1.136(a), to extend the time for filing a response to the outstanding Office Action by the number of months which will avoid abandonment under 37 C.F.R. § 1.135. The fee under 37 C.F.R. § 1.17 should be charged to our Deposit Account No. 15-0700.

AMENDMENTS

_X_ If checked, amendment(s) to the specification and/or claims are submitted herewith.

1. ___ If checked, an abstract is submitted as the last page of Appendix A.

2. **Specification:**

Please delete the paragraph(s)/section(s) beginning at page, and replace such paragraph(s)/section(s) pursuant to 37 C.F.R. § 1.121(b)(ii) with the "clean" version attached hereto as Appendix A. Entry is respectfully requested. A version with markings to show the changes made pursuant to 37 C.F.R. § 1.121(b)(iii) is attached hereto as Appendix B.

3. **Claims:**

Please cancel claims _____ without prejudice.

Please amend claims 4, 6 and 8-11 pursuant to 37 C.F.R. § 1.121(c)(i) as set forth in the "clean" version attached hereto as Appendix A. Entry is respectfully requested. A version with markings to show the changes made pursuant to 37 C.F.R. § 1.121(c)(ii) is attached hereto as Appendix B.

___ If checked, the optional complete set of "clean" claims pursuant to 37 C.F.R. § 1.121(c)(3) is attached hereto as Appendix C.

REMARKS/ARGUMENT

This Preliminary Amendment is being submitted to change the multiple dependent claims to single dependent claims in order to reduce the government filing fee.

EXPRESS MAIL CERTIFICATE

I hereby certify that this correspondence is being deposited with the United States Postal Service as Express Mail to Addressee (mail label # EL924390194US) in an envelope addressed to: U.S. Patent and Trademark Office, P.O. Box 2327, Arlington, VA 22202 on January 7, 2002:

Dorothy Jenkins
Name of Person Mailing Correspondence

Dorothy Jenkins
Signature

January 7, 2002
Date of Signature

Respectfully submitted,

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APPENDIX A
"CLEAN" VERSION OF EACH PARAGRAPH/SECTION/CLAIM
37 C.F.R. § 1.121(b)(ii) AND (c)(i)

CLAIMS (with indication of amended or new):

(Amended) 4. A laser arrangement according to claim 2, characterized in that a respective polarization-sensitive beam divider (10, 5) is provided in the path of the laser beam (6) on both sides of the polarization rotating means (8).

(Amended) 6. A laser arrangement according to claim 1, characterized in that the means for passive mode-locking is a saturable absorber (15).

(Amended) 8. A laser arrangement according to claim 6, characterized in that the saturable absorber (15) is an absorber mirror terminating the one resonator arm (11).

(Amended) 9. A laser arrangement according to claim 1, characterized in that in the one resonator arm (11) which is active in the pulse forming phase (21), a linear loss element, e.g. a l/4 platelett (13), is arranged which provides for a high energy accumulation in the laser crystal (3).

(Amended) 10. A laser arrangement according to claim 2, characterized in that the pump unit (2) is a continuous wave diode pump unit forming, in combination with the polarization rotating means (8), a resonator part (20) common to both resonator arms (11, 12).

(Amended) 11. A laser arrangement according to claim 2, characterized in that the pump unit (2) is lamp-pumped or laser-pumped, forming, in combination with the polarization rotating means (8), a resonator part (20) common to both resonator arms (11, 12).

APPENDIX B

VERSION WITH MARKINGS TO SHOW CHANGES MADE
37 C.F.R. § 1.121(b)(iii) AND (c)(ii)

CLAIMS:

4. A laser arrangement according to claim 2 [or 3], characterized in that a respective polarization-sensitive beam divider (10, 5) is provided in the path of the laser beam (6) on both sides of the polarization rotating means (8).

6. A laser arrangement according to [any one of claims 1 to 5] claim 1, characterized in that the means for passive mode-locking is a saturable absorber (15).

8. A laser arrangement according to claim 6 [or 7], characterized in that the saturable absorber (15) is an absorber mirror terminating the one resonator arm (11).

9. A laser arrangement according to [any one of claims 1 to 8] claim 1, characterized in that in the one resonator arm (11) which is active in the pulse forming phase (21), a linear loss element, e.g. a l/4 platelett (13), is arranged which provides for a high energy accumulation in the laser crystal (3).

10. A laser arrangement according to [any one of claims 2 to 9] claim 2, characterized in that the pump unit (2) is a continuous wave diode pump unit forming, in combination with the polarization rotating means (8), a resonator part (20) common to both resonator arms (11, 12).

11. A laser arrangement according to [any one of claims 2 to 10] claim 2, characterized in that the pump unit (2) is lamp-pumped or laser-pumped, forming, in combination with the polarization rotating means (8), a resonator part (20) common to both resonator arms (11, 12).

A Laser Arrangement

The invention relates to a laser arrangement comprising a pump unit containing a pumped laser crystal, and further comprising means for passive mode-locking.

Such laser arrangements are particularly provided as short pulse laser arrangements, wherein short laser pulses are generated with high energy in the mode-locked state. These short pulse laser arrangements are advantageously used for high-precision material processing or for scientific tasks. As regards the generation of short laser pulses, reference may be made, e.g., to the general statements in WO 98/10494 A as well as in A. Stingl et al.: Generation of 11-fs pulses from a Ti:sapphire laser without the use of prisms; Optics Letters Vol. 19, No. 3, 1 February 1994, pp. 204-206.

The standard technique for generating short laser pulses with high energy is based on the technique of a laser oscillator and a laser amplifier. The laser oscillator generates a sequence of short laser pulses of low energy, e.g. with a repetition frequency in the range of some ten Mhz. From these oscillator pulses, pulses with a lower repetition frequency are selected and amplified in a regenerative or so-called multi-pass amplifier to give pulses of high energy.

An all-in-one concept is preferably used, in which merely one laser is provided which is used both as os-

cillator and also as regenerative amplifier, by simply performing the pulse formation (at low energies) on the one hand, and the amplification (to high energies), on the other hand, at different times. Known laser arrangements of this type (cf. e.g. L. Turi, T. Juhasz: Diode-pumped Nd:YLF all-in-one laser; Optics Letters Vol. 20, No. 14, 15 July 1995, pp. 1541-1543), comprising a laser both for the oscillator function and also for the amplifier function, use active mode-locking with an acousto-optic modulator. Since the active mode-locking is not very efficient, the minimum pulse duration obtainable is relatively long, and moreover, a complex electronic circuitry is required for the time control and stabilization, respectively, to achieve a reliable long-term operation.

On the other hand, in laser arrangements it is generally known - as results from the previously mentioned document WO 98/10494 A, to design a passive mode-locking, in particular also with a saturable absorber. Other possible ways for passive mode-locking are, e.g., the utilization of the Kerr effect (so-called Kerr lens mode-locking, KLM), the use of non-linear mirrors (non-linear mirror mode-locking, NLM), the application of a non-linear polarization rotation in optic crystals or cascaded non-linear processes of the second order.

It is now an object of the invention to provide a

laser arrangement of the initially defined type which, when using a passive mode-locking, allows for an all-in-one construction of the laser, wherein the advantage is used that a passive mode-locking causes a much stronger amplitude modulation than an active mode-locking and stable short pulses in the pico- or femto-second range can be generated, i.e. with pulse durations near the possible lower limit value, which is given by the finite amplification bandwidth of the laser material used. Here, also the problem must be solved that passive mode-locking devices, such as saturable absorbers, on the other hand provide an upper limit to the raising of the energy, due to their low destruction threshold value, and moreover, with an excessive saturation of the absorber, also instabilities are caused. The invention now is based on the idea to distribute the resonator to two different sub-resonators active at different times, with the sub-resonators providing the different tasks, i.e. the pulse formation by using the passive mode-locking, on the one hand, with high resonator losses corresponding to the low power levels, and, on the other hand, the amplification to high pulse energies.

The inventive laser arrangement of the initially defined type therefore is characterized in that two separate, alternatively switchable resonator arms are provided, one of which, which is active in the one

pulse forming phase, comprises the means for passive mode-locking, whereas the other resonator arm, which is active in an amplifying phase, is free from components that introduce losses. In the present laser arrangement, thus, different resonator parts are used at different times, wherein in the one phase, when the short laser pulses having a low energy are generated, the one resonator arm is active with the arrangement for passive mode-locking, with high resonator losses corresponding to the low power values prevailing; after the pulse formation, the resonator is switched over so that the other resonator arm becomes active, wherein the means for passive mode-locking is no longer present in the resonator, and an amplification to high pulse energies becomes possible with a view to the high resonator quality of the resonator now active.

Suitably, the polarization of the laser beam is utilized for switching, and accordingly, for a simple embodiment of the laser arrangement it may be provided that for switching between the two resonator arms, at least one polarization-sensitive beam divider as well as a polarization rotating means is provided. To this end, preferably a Pockels cell is used as the polarization rotating means; such a Pockels cell may be controlled electrically so as to rotate the polarization direction of the laser beam passing therethrough - by 90°. In combination with another appropriate polariza-

tion-sensitive beam divider, thus, the laser beam can be directed into the other resonator arm after this switching.

It is particularly advantageous if one polarization-sensitive beam divider each is arranged in the path of the laser beam on either side of the polarization rotating means. In this instance, the polarization-sensitive beam divider provided on the side of the polarization-rotating means facing away from the means for passive mode-locking may form a laser beam out-coupling element so as to couple out the amplified laser pulses.

As a means for passive mode-locking, preferably a saturable absorber is used, as is known per se.

The saturable absorber advantageously may be a per se known saturable semiconductor absorber.

Moreover, for a compact, efficient resonator embodiment it is also advantageous if the saturable absorber is an absorber mirror terminating the one resonator arm, which absorber mirror in particular is semiconductor-based.

To introduce the desired losses in the laser beam during the pulse forming phase, it is also suitable to provide a linear loss element, e.g. a $\lambda/4$ platelett, in the one resonator arm which is active in the pulse forming phase, which platelett provides for a high energy accumulation in the laser crystal.

For designing the laser arrangement as an all-in-one laser system, finally, it is also suitable if the pumping unit is a continuous wave diode pumping unit and, together with the polarization rotating means, forms a resonator part common to both resonator arms. Moreover, it is advantageous if the pumping unit is lamp-pumped or laser-pumped and, together with the polarization rotating means, forms a resonator part common to both resonator arms.

In the following, the invention will be explained in more detail by way of a preferred exemplary embodiment illustrated in the drawing to which, however, it shall not be restricted.

Fig. 1 shows a schematic short-pulse laser arrangement according to the all-in-one design; and

Fig. 2 shows an associated diagram.

In the drawing, in Fig. 1 an all-in-one short pulse laser arrangement is illustrated and generally denoted by 1 which comprises a pump unit 2 that contains a - merely schematically indicated - diode-pumped laser crystal 3. On the one side of this pumping unit 2, a reonator end mirror 4 is provided.

On the other side of the pump unit 2, a polarization-sensitive beam divider 5 is provided which simultaneously forms an out-coupling element for the amplified laser beam 6, as is schematically indicated by the arrow 7. During its round trip in the indicated

resonator, the laser beam 6 gets to a polarization rotating means in the form of a Pockels cell 8 which, as denoted at 9, can be electrically controlled in a manner known per se and therefore merely shortly explained in the following, so as to rotate the polarization of the laser beam 6 by 90°.

In the path of the laser beam 6, there follows a further polarization-sensitive beam divider 10 which, depending on the polarization of the laser beam 6, allows the laser beam 6 to pass therethrough (i.e., in the one laser resonator arm 11) or reflects the same (i.e. in the other laser resonator arm 12). In Fig. 1, the polarization of the laser beam 6 in the one resonator arm 11 is schematically indicated by a double arrow and in the other resonator arm 12 by a dot in the circle, the double arrow indicating that the polarization direction is in the plane of drawing, whereas the dot in the circle for the other resonator arm 12 indicates that the polarization direction of the laser beam 6 is perpendicular to the plane of drawing.

In the one resonator arm 11, in the path of the laser beam 6 there follows a $\lambda/4$ platelett 13 which introduces the required losses in the laser beam 6, whereafter the laser beam 6 is reflected by a mirror 14 to a saturable semiconductor-absorber mirror 15 which is provided as means for passive mode-locking. Such saturable semiconductor absorber mirrors are known per

se so that no further explanation is required.

In the other resonator arm 12, the laser beam 6 is guided via four mirrors 16 to 19 so as to obtain the required length of travel, wherein the mirrors 17 and 18 are spherical focussing mirrors, whereas mirrors 16 and 19 are highly reflecting plane mirrors.

As may be seen, the elements 4, 2, 3, 5, 8 thus together form a resonator part 20 which, depending on the polarization direction of the laser beam 6 at the beam divider 10, then either will be supplemented by the one resonator arm 11 or by the other resonator arm 12 so as to form the entire laser resonator. The one laser resonator having the length L1 thus is formed by the elements 4, 2, 3, 5, 8, 10, 13, 14 and 15, and it is responsible for the pulse build-up phase (pulse forming phase) 21 (cf. Fig. 2); the other resonator having the length L2, however, is formed by the elements 4, 2, 3, 5, 8, 10, 16, 17, 18 and 19 and is responsible for amplification (amplifying phase 22 in Fig. 2).

In the pulse forming phase 21 in which no voltage is applied to the Pockels cell 8, the one resonator arm 11, as mentioned, is effective. The two beam dividers 5 and 10 allow the laser beam 6 to pass therethrough, since the latter at this time is linearly polarized in the plane of the drawing, cf. the double arrows at the two beam dividers 5 and 10. The $\lambda/4$ platelett 13 is ad-

justed to introduce high losses into the system and thus to keep low the power level in the resonator 20-11 and to cause a high inversion in the laser crystal 3. Since the saturable absorber mirror 15 is located in the one resonator arm 11, the desired short laser pulses develop. This is shown in Fig. 2 in the upper diagram line, in which the pulse intensity I(3/4), measured at a site between the pump unit 2 with the laser crystal 3 and the end mirror 4, is drawn; as is apparent, the pulses having a distance $t_1 = 2L1/c_0$ (with c_0 = laser beam speed) progressively become shorter.

To switch over to the amplifying phase 22, a $\lambda/2$ voltage $U_{\lambda/2}$ given by the respective Pockels cell 8 is applied to the Pockels cell 8, at 9, by a per se common control electronic circuitry (cf. also the second line in Fig. 2 which shows the course of the voltage U_{PC} at the Pockels cell 8 in dependence on the time t). This control must be effected at a time T1, at which the laser pulse which circulates in the resonator, is just on the right-hand side of the Pockels cell 8 according to the illustration in Fig. 1, i.e. in the region of the beam divider 5 or of the pump unit 2, respectively, or the end mirror 4, respectively. As a rule, a Pockels cell already contains a driver circuit in which such times can be adjusted. Thus, in Fig. 1 a rapid high voltage switch 23 is shown merely schematically, to

which a high voltage $U_{\lambda/2}$ is supplied at 24, and which has an associated circuit 25 for generating an electrical pulse to switch the high voltage switch 23, or the Pockels cell 8, respectively, at the times T1 and T2, respectively. Fig. 1 moreover schematically shows an externally adjustable time control element 26 to thus indicate the adjustment of times T1, T2. Elements 23 to 26 thus form an electronic control unit which is indicated at 27 in Fig. 1, which control unit is provided for switching the laser beam via the Pockels cell 8.

If the laser pulse then reaches the Pockels cell 8, due to the driving of the latter at time T1 (cf. also Fig. 2), the polarization is rotated by 90° so that it will extend perpendicular to the plane of drawing. The laser pulse then will no longer be allowed by the beam divider 10 to pass to the one resonator arm 11 provided for the pulse forming phase 21, but it will be reflected to the other resonator arm 12, passing through the system comprising the mirrors 16 to 19 and finally being reflected by the beam divider 10 back to the Pockels cell 8 - where it is again rotated in its polarization by 90°. Since in this other resonator arm 12 elements introducing losses are not contained, the energy of the laser pulses will be rapidly increased by any round trip, cf. also Fig. 2, first diagram line, graph of the pulse intensity I (3/4).

When the pulse energy has reached its saturation

value, the Pockels cell 8 is switched off. This switching off is effected at a time T2 at which the laser pulse is at the left of the Pockels cell 8, i.e. in the other resonator arm 12 provided for the amplifying phase 22. If the laser beam 6 now passes the Pockels cell 8 arriving from the left-hand side, the polarization will no longer be rotated by 90° (i.e. into the plane of drawing), since the voltage $U_{\lambda/2}$ has already been switched off by the Pockels cell 8 (i.e., the voltage U_{PC} at the Pockels cell 8 is 0 V again); since the polarization now has remained perpendicular to the plane of drawing, the laser pulse is coupled out by being reflected at the beam divider 5, cf. the arrow 7, instead of being allowed to pass to the pump unit 2. This amplified output pulse is illustrated in the third diagram line of Fig. 2, for the intensity I(7) of the pulse at outcoupling, cf. arrow 7 in Fig. 1.

In the system described the polarization within laser crystal 3 will always remain the same (i.e., according to the illustration of Fig. 1, in the drawing plane) so that any laser medium may be used without having to take into consideration a polarization-dependent amplification.

Claims:

1. A laser arrangement (1) comprising a pump unit (2) containing a pumped laser crystal (3), and further comprising means (15) for passive mode-locking, characterized in that two separate, alternatively switchable resonator arms (11, 12) are provided, one resonator arm (11) of which, which is active in a pulse forming phase (21), comprises the means (15) for passive mode-locking, whereas the other resonator arm (12), which is active in an amplifying phase (22), is free from components that introduce losses.

2. A laser arrangement according to claim 1, characterized in that at least one polarization-sensitive beam divider (10) as well as a polarization rotating means (8) is provided for switching between the two resonator arms (11, 12).

3. A laser arrangement according to claim 2, characterized in that the polarization rotating means (8) is formed by a Pockels cell.

4. A laser arrangement according to claim 2 or 3, characterized in that a respective polarization-sensitive beam divider (10, 5) is provided in the path of the laser beam (6) on both sides of the polarization

rotating means (8).

5. A laser arrangement according to claim 4, characterized in that on the side of the polarization-rotating means (8) opposite to the means (15) for passive mode-locking, the polarization-sensitive beam divider (5) simultaneously forms a laser beam-outcoupling element.

6. A laser arrangement according to any one of claims 1 to 5, characterized in that the means for passive mode-locking is a saturable absorber (15).

7. A laser arrangement according to claim 6, characterized in that the saturable absorber (15) is a saturable semiconductor absorber.

8. A laser arrangement according to claim 6 or 7, characterized in that the saturable absorber (15) is an absorber mirror terminating the one resonator arm (11).

9. A laser arrangement according to any one of claims 1 to 8, characterized in that in the one resonator arm (11) which is active in the pulse forming phase (21), a linear loss element, e.g. a $\lambda/4$ platelett (13), is arranged which provides for a high energy accumulation in the laser crystal (3).

10. A laser arrangement according to any one of claims 2 to 9, characterized in that the pump unit (2) is a continuous wave diode pump unit forming, in combination with the polarization rotating means (8), a resonator part (20) common to both resonator arms (11, 12).

11. A laser arrangement according to any one of claims 2 to 10, characterized in that the pump unit (2) is lamp-pumped or laser-pumped, forming, in combination with the polarization rotating means (8), a resonator part (20) common to both resonator arms (11, 12).

Abstract

A Laser Arrangement

A laser arrangement (1) comprising a pump unit (2) containing a pumped laser crystal (3), and means, such as a saturable absorber (15), for passive mode-locking, wherein two separate, alternatively switchable resonator arms (11, 12) are provided, one resonator arm (11) of which, which is active in a pulse forming phase (21), comprises the saturable absorber (15), whereas the other resonator arm (12), which is active in an amplifying phase (22), is free from components that introduce losses.

FIG. 1

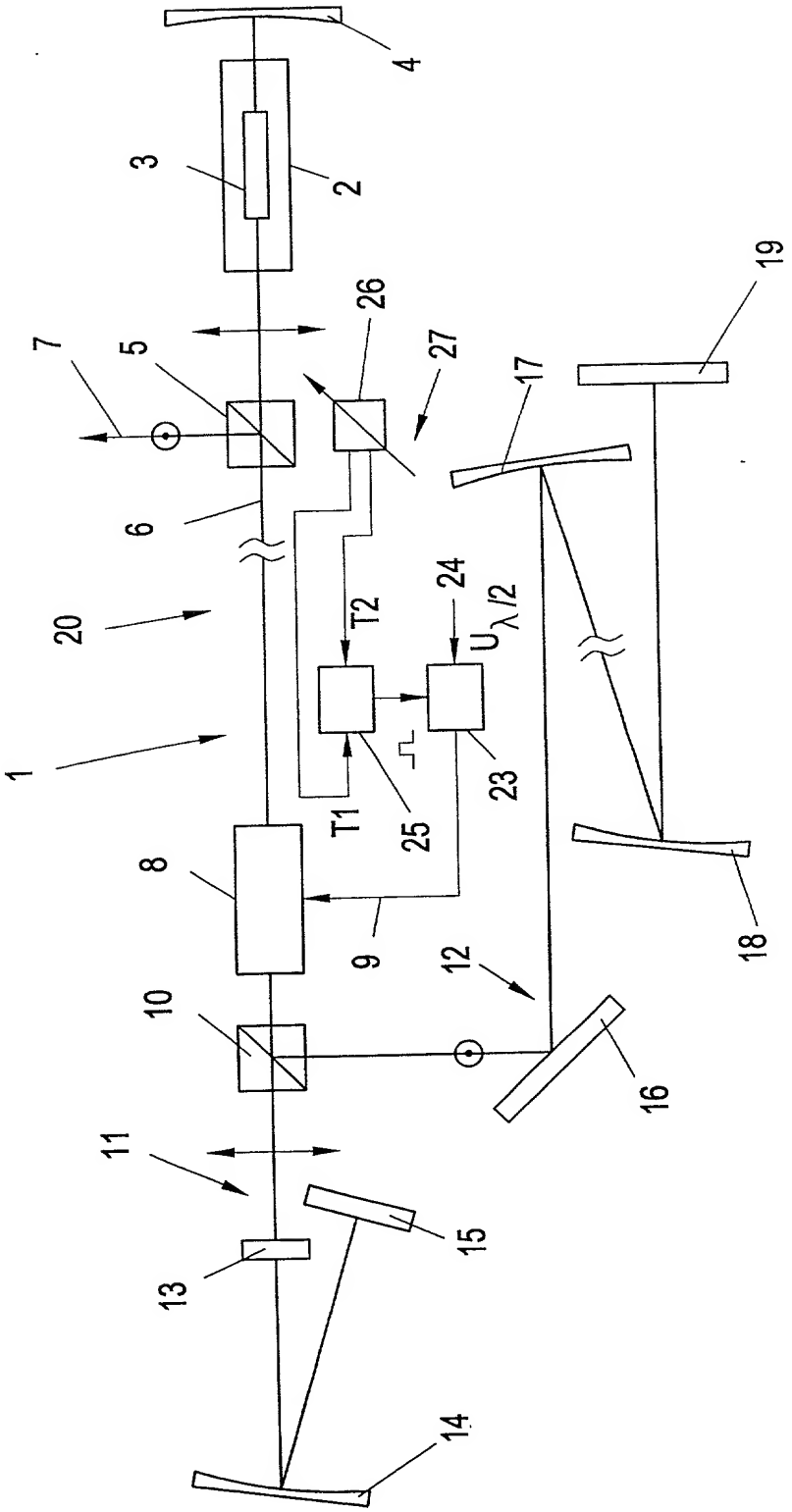
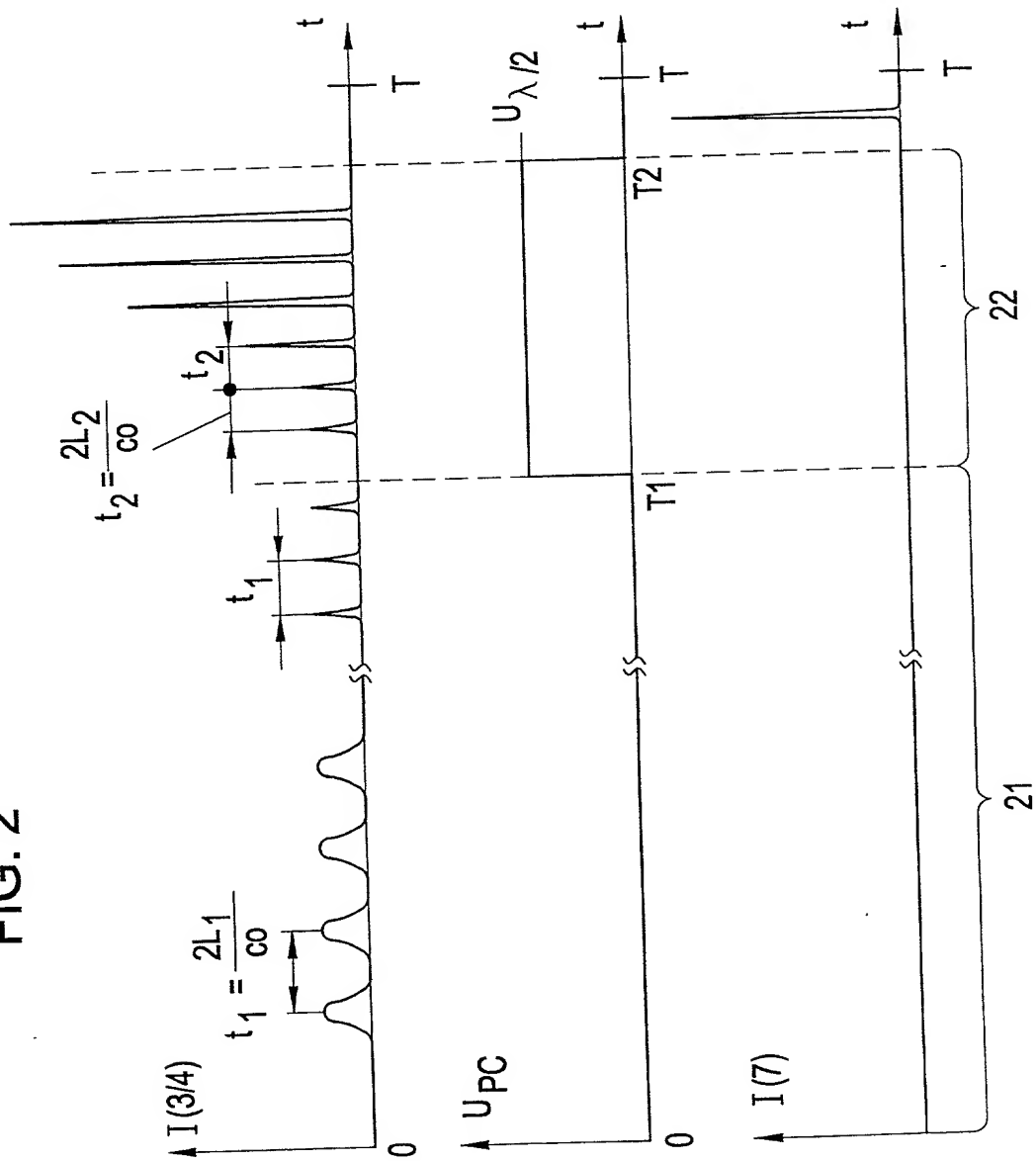


FIG. 2



UNITED STATES OF AMERICA COMBINED DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION	OFGS FILE NO.

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that I verily believe that I am the original, first and sole inventor (if only one name is listed below) or a joint inventor (if plural inventors are named) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Laser Device

the specification of which is attached hereto, unless the following box is checked:

☒ was filed on 26 June 2000 as United States patent Application Number or PCT International patent Number PCT/AT00/00173 and was amended on _____ (if any).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information known to be material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim priority benefits under Title 35, United States Code §119 of any foreign application(s) for patent or inventor's certificate or United States provisional application(s) listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign or Provisional Application(s)

COUNTRY	APPLICATION NUMBER	DATE OF FILING *(day, month, year)*	PRIORITY CLAIMED UNDER 35 U.S.C. 119
Austria	A 1159/1999	7 July 1999	YES X NO ___
			YES ___ NO ___
			YES ___ NO ___

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

UNITED STATES APPLICATION NUMBER	DATE OF FILING *(day, month, year)*	STATUS (patented, pending, abandoned)

I hereby appoint OSTROLENK, FABER, GERB & SOFFEN, and the members of the firm, Marvin C. Soffen - Reg. No. 17,542; Samuel H. Weiner - Reg. No. 18,510; Jerome M. Berliner - Reg. No. 18,653; Robert C. Faber - Reg. No. 24,322; Edward A. Meilman - Reg. No. 24,735; Stanley H. Lieberstein - Reg. No. 22,400; Steven I. Weisburd - Reg. No. 27,409; Max Moskowitz - Reg. No. 30,576; Stephen A. Soffen - Reg. No. 31,063; James A. Finder - Reg. No. 30,173; William O. Gray, III - Reg. No. 30,944 and Louis C. Dujmich - Reg. No. 30,625, as attorneys with full power of substitution and revocation to prosecute this application, to transact all business in the Patent & Trademark Office connected herewith and to receive all correspondence.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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